EFFECTS OF LAND DISTURBANCE ON BUTTERFLIES (LEPIDOPTERA) ON A HILLTOP AT MURWILLUMBAH, NEW SOUTH WALES

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Abstract

A post-disturbance study of butterfly species richness and abundance was completed on the butterfly community of Hospital Hill, Murwillumbah, NSW. Butterfly species richness did not decline following disturbance; however a significant decrease in butterfly abundance was evident. Of the 21 hill-topping species known or thought to use Hospital Hill, a decrease in hill-topping activity was recorded for many species with one, *Polyura sempronius sempronius* (Fabricius) [Nymphalidae], virtually disappearing from the site.

Introduction

Hospital Hill is situated on the northern side of the business centre of Murwillumbah in northern New South Wales and is a dominant natural feature. The site is a habitat 'island' surrounded by extensive urban and agricultural development. Since 1930, it has been subjected to significant land disturbance, much of the original vegetation having been removed to accommodate water storage tanks, access roads and visitor facilities. Despite extensive clearing, many of the larger native trees have been retained and regrowth has occurred in many areas that were originally cleared. The Hospital Hill vegetation community comprises wet sclerophyll open forest and woodland species (Ecograph 2002). Dominant tree species include tallowwood (*Eucalyptus microcorys*), brush box (*Lophostemon confertus*) and pink bloodwood (*Eucalyptus intermedia*). In woodland areas, camphor laurel (*Cinnamomum camphora*) has become a major regrowth species. Eighteen butterfly larval food plant species have been recorded from the site.

Hill-topping in butterflies is a very complex behaviour which has been recognised as a mate location strategy, particularly in species which occur at low population densities (*e.g.* Shields 1967, Scott 1968, 1973, Atkins 1975, Common and Waterhouse 1981, Newland 1992, New 1997, Sands and New 2002). Factors that determine whether a site is used or not can be subtle (Baugham and Murphy 1988), and even small changes cause butterflies to abandon a site (Smithers 1996). The importance of hill-topping sites is out of proportion to their extent, so that a small area can be vital to the survival of species over a larger area, and the significance of competition among male butterflies has only recently been recognised as essential to preserving the genetic integrity of species which hilltop. Hilltops are also key sites for insects as prey for predatory birds and other invertebrates (Sands and New 2002).

A 13 megalitre reservoir was proposed by Tweed Shire Council for the summit of Hospital Hill, with site preparation work commencing in August 2003. The new reservoir, with a development footprint of 56 metres diameter,

replaces a 1.2 megalitre reservoir built in 1930. Available information suggested that the significance of the proposal on the value of Hospital Hill as a hill-topping butterfly site should be considered carefully (NSW National Parks and Wildlife Service 2003). The loss and/or degradation of sites used for hill-topping by butterflies is listed by the NSW Scientific Committee (2001) as a 'key threatening process' in Schedule 3 of the NSW Threatened Species Conservation Act 1995. A key threatening process is defined in this Act as 'a process that threatens, or could threaten, the survival or evolutionary development of species, populations or ecological communities'. The primary concern with respect to the impact of the proposal was that the development would contribute to the loss and/or degradation of Hospital Hill as a butterfly hill-topping site.

To determine effects of land disturbance associated with construction of the new reservoir on the use of Hospital Hill by butterflies, post-disturbance surveys were completed in 2003-2004 and compared with pre-disturbance surveys carried out by the author in 1991-1992. Butterfly species richness and abundance were the major criteria investigated, along with butterfly behaviour. Study of the effects of disturbance and the effectiveness of mitigation measures implemented has the potential to provide relevant, useful information that can be used to predict the impact of similar developments. Potential loss and/or degradation of summit sites used for hill-topping by butterflies is a matter other local government authorities are likely to have to consider when assessing proposed infrastructure developments at hilltop sites.

Materials and methods

Researchers, including Pollard (1977, 1982) and Thomas (1983), have developed techniques that estimate abundance and species richness in selected areas. These techniques involve walking along a predetermined route and recording all butterflies encountered within a set distance from the observer. A similar method was adopted for the studies carried out on Hospital Hill, together with a set of fixed criteria to maximise consistency in data collection. Studies suggest that estimates of butterfly abundance based on transect counts are more accurate than previously thought and provide an adequate basis for assessing a butterfly's status and needs (Pollard 1982).

When completing each transect survey, the transect route was travelled at a slow walking pace and all butterflies seen within an area extending 5 metres in front of and 2.5 metres either side of the observer were recorded. These distances were found to be the limits that would allow accurate recording. The first transect was commenced around 0930 h. General observations were then carried out until 1300 h, when a second transect was completed. Additional observations, where possible, were carried out until mid to late afternoon. One limitation was the difficulty in locating butterflies perched high above in tree canopies, particularly cryptic, fast-flying species. For this

reason, some hill-topping species, including those of the lycaenid genera *Hypochrysops* C. & R. Felder and *Acrodipsas* Sands, may still remain unrecorded from Hospital Hill.

Post-disturbance surveys of the summit butterfly fauna were carried out on one day every month for 12 months, from August 2003 to July 2004, using the same methodology employed in the 1991-1992 study (Newland 2005). This allowed comparison of data from both pre-disturbance and post-disturbance stages to determine effects of development on the hilltop butterfly fauna. As the 1991-1992-study period extended from November to February, comparisons with the post-disturbance study period were made for these months only.

Butterfly species richness

Species richness is arguably the most widely used indicator of the ecological diversity of a given area. It is often used as the biological measure of a habitat when decisions are to be made concerning conservation and management. Two components of species richness – number of species and species present, were compared for the two study periods. Butterfly species richness was recorded for each month; including species sighted during the day's observations but not recorded in transect surveys.

Number of species

Total number of species

The total number of species, including hill-topping species, was similar for both study periods, with summit disturbance having little effect on this component of species richness. During the November 1991-February 1992 study, 47 butterfly species were identified at Hospital Hill. From November 2003 to February 2004, 50 species were observed. The slightly higher number recorded during the post-disturbance study period may be due to several inconspicuous species being overlooked in the 1991-1992 study. Figure 1 compares the total number of species recorded for these months.

Number of hill-topping species

Compared with the 1991-1992 survey, the 2003-2004 study yielded two additional hill-topping species, with a total of 17 species recorded during the post-disturbance survey. The two additional species observed during 2003-2004, *Netrocoryne repanda* C. & R. Felder and *Hypocysta metirius* Butler, may have been present in 1991-1992 but were probably overlooked. The post-disturbance study recorded generally lower monthly numbers of hill-topping species (Figure 2).

Including species observed outside the study periods, 21 butterfly species (Table 1) are now known or thought to use the Hospital Hill site as a mate-locating rendezvous. This represents 29% of all butterfly species recorded from the site.

Species present

All species

Appendix 1 lists all species observed from the site, including those observed outside the study periods. Although the number of species recorded for both study periods remained relatively unchanged, the species recorded for each study period differed slightly, perhaps reflecting natural population fluctuations.

Table 1. Hill-topping butterfly species known or thought to use the Hospital Hill site, Murwillumbah. C = common; U = uncommon; L = local in distribution. * = species with males less abundant after disturbance of site; ^ = species observed in the vicinity of Hospital Hill and which probably also use the hilltop as a mate locating site.

Butterfly species	Status
HESPERIIDAE	
Netrocoryne repanda repanda C. & R. Felder	C, L
Toxidia peron (Latreille) *	C
PAPILIONIDAE	
Protographium leosthenes leosthenes (Doubleday) *	U
Graphium macleayanum macleayanum (Leach) *	C
Graphium sarpedon choredon (C. & R. Felder) *	C
Papilio anactus W.S. Macleay *	C
Cressida cressida cressida (Fabricius)	U
PIERIDAE	
Delias nigrina (Fabricius) *	C
Delias argenthona argenthona (Fabricius) *	C
NYMPHALIDAE	
Hypocysta metirius Butler	C
Polyura sempronius sempronius (Fabricius) *	U
Acraea andromacha andromacha (Fabricius) *	C
Hypolimnas bolina nerina (Fabricius) *	C
Junonia villida calybe (Godart)	C
Vanessa kershawi (McCoy)	C
Vanessa itea (Fabricius) ^	C, L
LYCAENIDAE	
Hypochrysops delicia delicia Hewitson ^	U, L
Ogyris olane (Hewitson)	U, L
Ogyris zozine (Hewitson)	U, L
Deudorix diovis (Hewitson)	C, L
Candalides absimilis (C. Felder) *	C

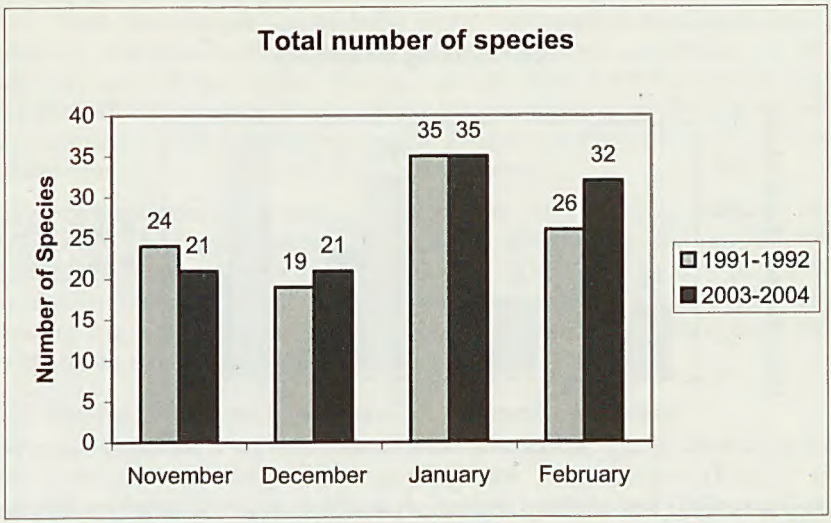

Fig. 1. Total number of species recorded from November to February at Hospital Hill, Murwillumbah, during 1991-1992 and 2003-2004.

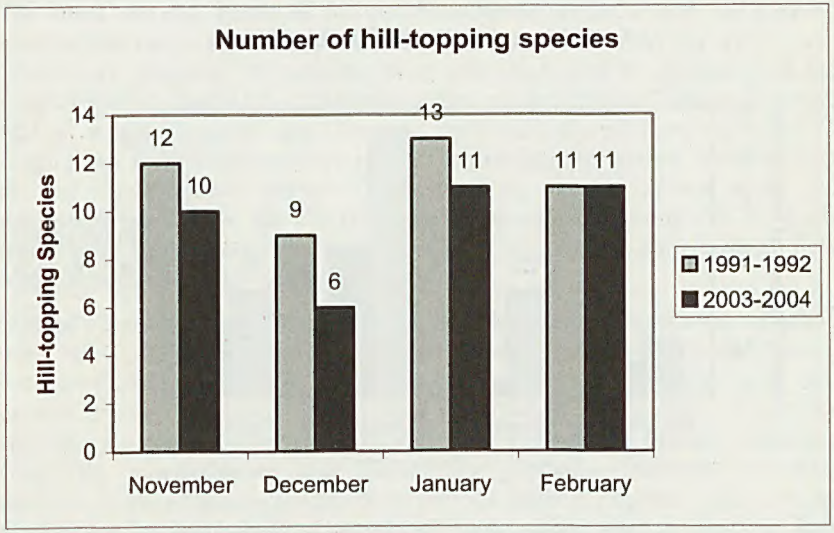

Fig. 2. Number of hill-topping species recorded from November to February at Hospital Hill, Murwillumbah, during 1991-1992 and 2003-2004.

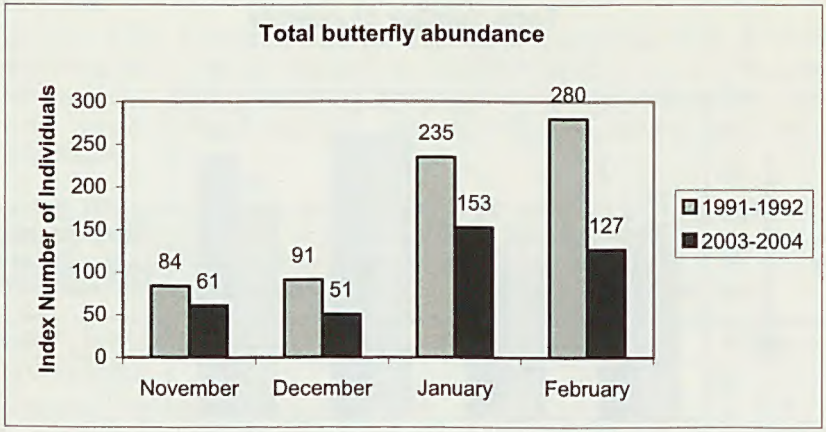

Fig. 3. Index of total butterfly abundance (individuals recorded during morning and afternoon transects) from November to February at Hospital Hill, Murwillumbah, during 1991-1992 and 2003-2004.

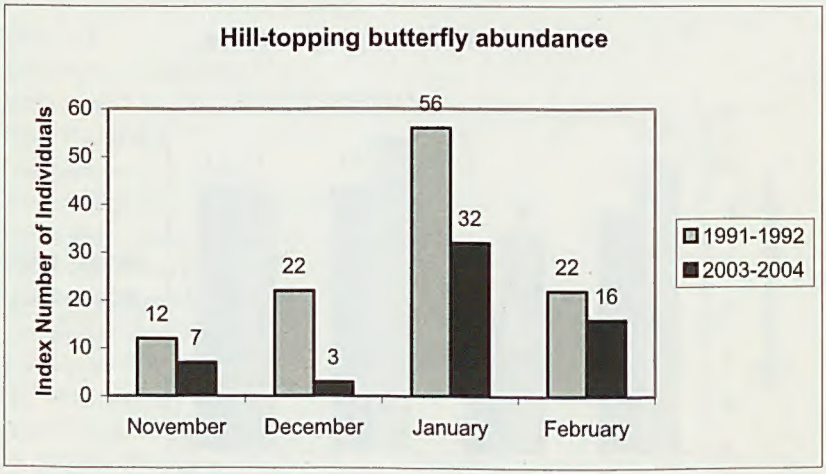

Fig. 4. Index of hill-topping butterfly abundance (individuals recorded during morning and afternoon transects) from November to February at Hospital Hill, Murwillumbah, during 1991-1992 and 2003-2004.

A small number of *Cupha prosope* (Fabricius) adults were observed in April-June 2004. This species was probably more widespread in the Tweed Valley prior to European settlement. The only other known occurrence of this butterfly is in Cudgen Nature reserve, north of Cabarita on the Tweed Coast. Hospital Hill is considered to constitute an important refuge for this species, as almost the entire surrounding coastal lowland rainforest habitat has been cleared for agriculture and residential development.

Seventy-four butterfly species have now been recorded from Hospital Hill (Appendix 1). This represents 35% of the 206 species known from the McPherson region (Dunn and Dunn 1991). When compared with the 96 species recorded from Mt Warning National Park (Newland 1999), it is evident that isolated remnant sites such as Hospital Hill represent important butterfly conservation refuges.

Hill-topping species

Several frequently observed, conspicuous hill-topping species were recorded for both study periods, including *Graphium macleayanum* (Leach), *G. sarpedon choredon* (C. & R. Felder), *Acraea andromacha* (Fabricius) and *Candalides absimilis* (C. Felder). Other, less conspicuous species, including *Netrocoryne repanda* and *Deudorix diovis* Hewitson, were recorded less frequently, being more difficult to detect. Table 1 lists all hill-topping species known or thought to use the site.

The most obvious result of hilltop disturbance on individual hill-topping species was the virtual disappearance of the nymphalid *Polyura sempronius* (Fabricius). Removal of perching sites and associated modification of the summit profile has had a detrimental effect on this species' use of Hospital Hill as a mate location site. Prior to the recent disturbance, males of *P. sempronius* were conspicuously present, patrolling the summit and perching on tree trunks, power poles and electrical or communications wires and equipment adjacent to the old 1.2 megalitre reservoir. Throughout the post-disturbance survey period, only one specimen was sighted, a male which flew over the summit briefly before departing.

Summit disturbance has also resulted in a decrease in abundance of many other hill-topping species. Although species which patrol close to the ground, such as *Papilio anactus* W.S. Macleay and *Acraea andromacha* were still present in the summit area, they were observed to be generally much less abundant or more sparsely distributed. Some high-flying species, including *Graphium macleayanum* and *Candalides absimilis*, suffered a similar decrease in abundance, although these species generally appear to have better adapted to loss of summit vegetation. Males were seen to modify their patrolling patterns following removal of mature summit trees, switching patrol areas to the tops of adjacent trees.

Butterfly abundance

Butterfly abundance was calculated as an index of the number of individuals recorded during both the morning and afternoons transect counts. Both total butterfly abundance and hill-topping butterfly abundance were significantly reduced following disturbance, despite the higher rainfall which occurred prior to and during the post-disturbance study (Figures 3, 4). This decrease in abundance reflects the loss of available habitat for both hill-topping and non-hilltopping butterfly species - a total of 0.2 hectares of hilltop habitat being lost as a result of vegetation clearing and site excavation for the new reservoir. This area was the highest point on Hospital Hill prior to the recent construction work and acted as a focus for much of the hill-topping activity for butterflies and other insects.

Discussion

Monitoring of the Hospital Hill butterfly fauna has enabled a detailed, quantitative assessment to be made of the effect of hilltop disturbance on the use of the site by butterflies. Although it is often difficult to determine if changes to the butterfly fauna at sites such as Hospital Hill are the result of human interference or are due to natural population fluctuation, results of this study suggest that decline in abundance of hill-topping males was a result of recent disturbance to the summit. A decrease in the ability of male butterflies to effectively compete for and mate with females has implications for the long term breeding success and maintenance of genetic fitness among local populations of affected species.

Results of this study also suggest that individual hill-topping species differ in their response to summit disturbance. Changes to the summit area adjacent to the old reservoir site have resulted in depletion or dispersal of hill-topping aggregations of many species which perch or patrol close to the ground. The virtual disappearance of *Polyura sempronius* confirms previous observations that even relatively small changes to the summit profile can cause some species to abandon a site. High-flying species, however, generally appear to have adapted better to disturbance, modifying their patrolling patterns in response to the altered summit vegetation profile. However, the reduction in tree canopy area would undoubtedly have reduced the total canopy area available for male butterflies to maintain individual territories.

Comparison of species richness alone to quantify effects of land disturbance on butterfly communities may lead to incorrect conclusions regarding the 'health' of butterfly hilltop communities. This study revealed a significant decline in populations of hill-topping species, although overall species richness was not affected. Assessment of effects of land disturbance on butterfly communities, therefore, should compare both species richness and abundance to more accurately quantify the effects of disturbance on sites thought to be important to the reproductive life cycles of butterflies. This is

of particular relevance if similar proposals are planned for other hilltops known or thought to support local butterfly populations which are geographically isolated or genetically distinct.

Promotion of native species regrowth and establishment of suitable nectar sources around the summit of Hospital Hill may assist in eventually mitigating negative effects of summit disturbance. Future surveys at this site should provide an indication of the effectiveness of compensatory plantings in restoring the abundance of depleted hill-topping butterfly species populations. When planning for and designing infrastructure such as observation towers, communications facilities and water reservoirs, careful consideration should be given to the effects of land disturbance to summit areas that are known or thought to serve as hill-topping sites. Siting of infrastructure a small distance below the summit (10-30 m) and minimising vegetation disturbance in order to preserve the summit profile, would greatly assist in ensuring the long-term survival and genetic fitness of hill-topping butterflies and other insects.

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Appendix 1

Butterfly species observed from 1977 to 2004 at Hospital Hill, Murwillumbah, NSW. Status (relative abundance): C = common; U = uncommon; L = local in distribution; S = sporadic in occurrence.

Butterfly species	Status
HESPERIIDAE	
Euschemon rafflesia rafflesia (W.S. Macleay)	U
Chaetocneme beata (Hewitson)	C, L
Netrocoryne repanda repanda C. & R. Felder	C, L
Hasora discolor mastusia Fruhstorfer	C
Hasora khoda haslia Swinhoe	C
Badamia exclamationis (Fabricius)	S
Trapezites symmomus symmomus Hübner	C
Toxidia rietmanni rietmanni (Semper)	C, L
Toxidia parvula (Plötz)	C, L
Toxidia peron (Latreille)	C
Ocybadistes flavovittatus flavovittatus (Latreille)	C

Butterfly species	Status
HESPERIIDAE (cont.)	
Ocybadistes walkeri sothis Waterhouse	C
Telicota colon argeus (Plötz)	C
Suniana sunias rectivitta (Mabille)	C
Telicota anisodesma Lower	C, L
Cephrenes augaides sperthias (C. Felder)	C
Cephrenes trichopepla (Lower)	C
PAPILIONIDAE	
Protographium leosthenes leosthenes (Doubleday)	U
Graphium macleayanum macleayanum (Leach)	C
Graphium sarpedon choredon (C. & R. Felder)	C
Graphium eurypylus lycaon (C. & R. Felder)	C
Papilio anactus W.S. Macleay	C
Papilio aegeus aegeus Donovan	C
Papilio fuscus capaneus Westwood	U
Cressida cressida cressida (Fabricius)	U
PIERIDAE	
Catopsilia pyranthe crokera (W.S. Macleay)	C
Catopsilia pomona (Fabricius)	C
Catopsilia gorgophone (Boisduval)	S
Eurema smilax smilax (Donovan)	C
Eurema hecabe hecabe (Linnaeus)	C
Elodina parthia (Hewitson)	S
Elodina angulipennis (P.H. Lucas)	C
Belenois java teutonia (Fabricius)	C
Cepora perimale scyllara (W.S. Macleay)	C
Appias paulina ega (Boisduval)	C
Delias nigrina (Fabricius)	C
Delias argenthona argenthona (Fabricius)	C
Pieris rapae rapae (Linnaeus)	C
NYMPHALIDAE	
Melanitis leda bankia (Fabricius)	C
Hypocysta metirius Butler	C
Heteronympha merope merope (Fabricius)	S
Polyura sempronius sempronius (Fabricius)	U
Acraea andromacha andromacha (Fabricius)	C
Cupha prosope prosope (Fabricius)	U, L
Phaedyma shepherdi shepherdi (Moore)	C

Butterfly species	Status
NYMPHALIDAE (cont.)	
Doleschallia bisaltide australis (C. & R. Felder)	U
Hypolimnas bolina nerina (Fabricius)	C
Junonia villida calybe (Godart)	C
Vanessa kershawi (McCoy)	C
Vanessa itea (Fabricius)	C, L
Tirumala hamata hamata (W.S. Macleay)	C
Danaus petilia (Stoll)	C
Danaus affinis affinis (Fabricius)	C
Danaus plexippus (Linnaeus)	C
Euploea tulliolus tulliolus (Fabricius)	U
Euploea core corinna (W.S. Macleay)	C
LYCAENIDAE	
Hypochrysops delicia delicia Hewitson	U, L
Ogyris olane (Hewitson)	U, L
Ogyris zozine (Hewitson)	U, L
Deudorix diovis (Hewitson)	C, L
Candalides absimilis (C. Felder)	C
Nacaduba berenice berenice (Herrich-Schäffer)	C
Nacaduba kurava parma (Waterhouse & Lyell)	C
Erysichton lineata lineata (Murray)	C
Pyschonotis caelius taygetus (C. & R. Felder)	C
Prosotas felderi (Murray)	C
Catopyrops florinda halys (Waterhouse)	C
Jamides phaseli (Mathew)	U
Catochrysops panormus platissa (Herrich-Schäffer)	U
Lampides boeticus (Linnaeus)	C
Leptotes plinius pseudocassius (Murray)	C
Zizina labradus labradus (Godart)	C
Everes lacturnus australis Couchman	U
Euchrysops cnejus cnidus Waterhouse & Lyell	U